US008817946B2

(12) **United States Patent**
Kobayashi

(10) **Patent No.: US 8,817,946 B2**
(45) **Date of Patent: Aug. 26, 2014**

(54) **X-RAY DETECTOR AND X-RAY CT APPARATUS**

(75) Inventor: **Hiroyuki Kobayashi**, Tokyo (JP)

(73) Assignee: **Hitachi Medical Corporation**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/515,869**

(22) PCT Filed: **Dec. 9, 2010**

(86) PCT No.: **PCT/JP2010/072115**

§ 371 (c)(1),
(2), (4) Date: **Jun. 14, 2012**

(87) PCT Pub. No.: **WO2011/074470**

PCT Pub. Date: **Jun. 23, 2011**

(65) **Prior Publication Data**

US 2012/0257715 A1 Oct. 11, 2012

(30) **Foreign Application Priority Data**

Dec. 16, 2009 (JP) 2009-285089
Jun. 21, 2010 (JP) 2010-140061

(51) **Int. Cl.**

G01T 1/20	(2006.01)
A61B 6/03	(2006.01)
A61B 6/00	(2006.01)
A61B 6/06	(2006.01)
G01T 1/29	(2006.01)
G21K 1/02	(2006.01)
A61B 6/04	(2006.01)

(52) **U.S. Cl.**

CPC ***G01T 1/2985*** (2013.01); ***A61B 6/42*** (2013.01); ***A61B 6/06*** (2013.01); ***A61B 6/4291*** (2013.01); *A61B 6/4233* (2013.01); *G21K 1/025* (2013.01); ***A61B 6/035*** (2013.01); ***A61B 6/5282*** (2013.01); *A61B 6/0457* (2013.01); ***A61B 6/032*** (2013.01)

USPC **378/19**; 250/366

(58) **Field of Classification Search**

USPC 378/19; 250/366

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,396,898	B1 *	5/2002	Saito et al.	378/19
7,492,857	B2 *	2/2009	Yasunaga et al.	378/19
2002/0064252	A1 *	5/2002	Igarashi et al.	378/19
2005/0117697	A1 *	6/2005	Yasunaga et al.	378/19
2010/0239072	A1 *	9/2010	Kurochi	378/147

FOREIGN PATENT DOCUMENTS

JP	10-314157	12/1998
JP	2002-162472	6/2002
JP	2007-117677	5/2007

OTHER PUBLICATIONS

International Search Report in PCT/JP2010/072115.

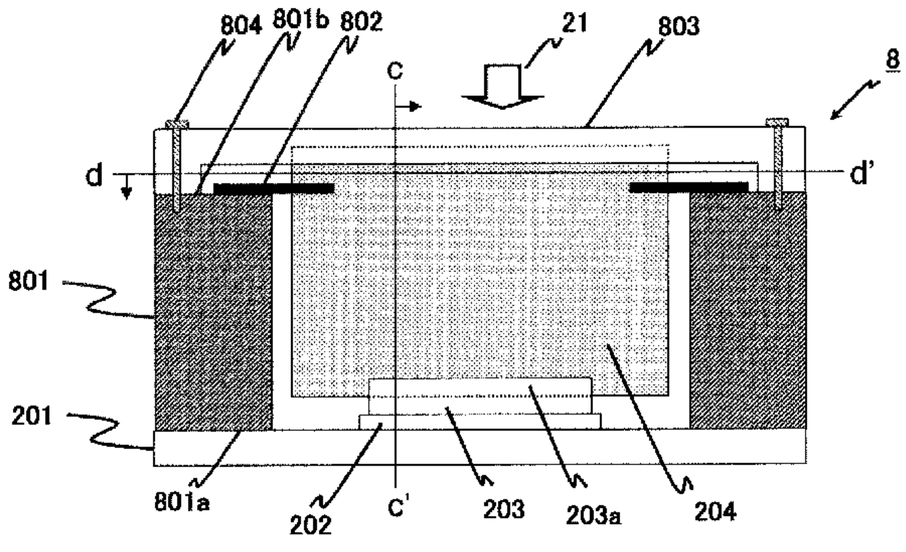
* cited by examiner

Primary Examiner — Allen C. Ho
Assistant Examiner — Danielle Fox
(74) *Attorney, Agent, or Firm* — Cooper & Dunham LLP

(57) **ABSTRACT**

There are provided an X-ray detector, which can reduce the deformation of a collimator plate and can be easily processed and installed, and an X-ray CT apparatus using it. The X-ray detector includes a collimator plate, and a scintillator array, a photoelectric conversion element array and a substrate that are bonded in order from the X-ray incidence direction. The collimator plate is disposed such that one of a pair of opposite sides of the collimator plate is bonded to a lower support plate bonded on the scintillator array and the other side is bonded to an upper support plate and directions of the opposite sides are the same as a rotation axis direction of an X-ray CT apparatus in which the X-ray detector is provided.

9 Claims, 7 Drawing Sheets



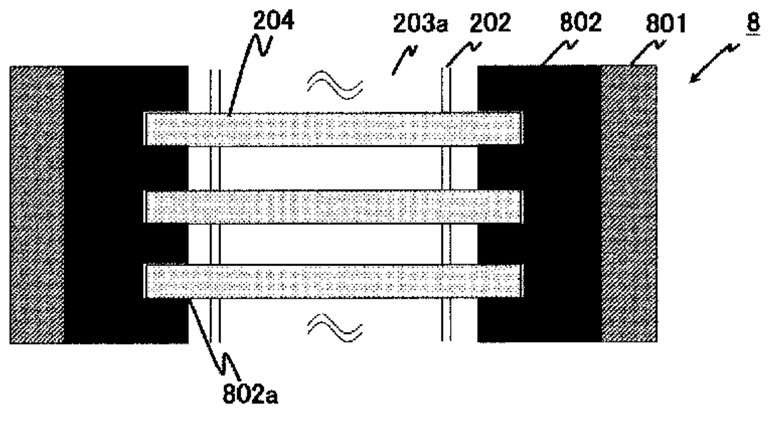


FIG. 1

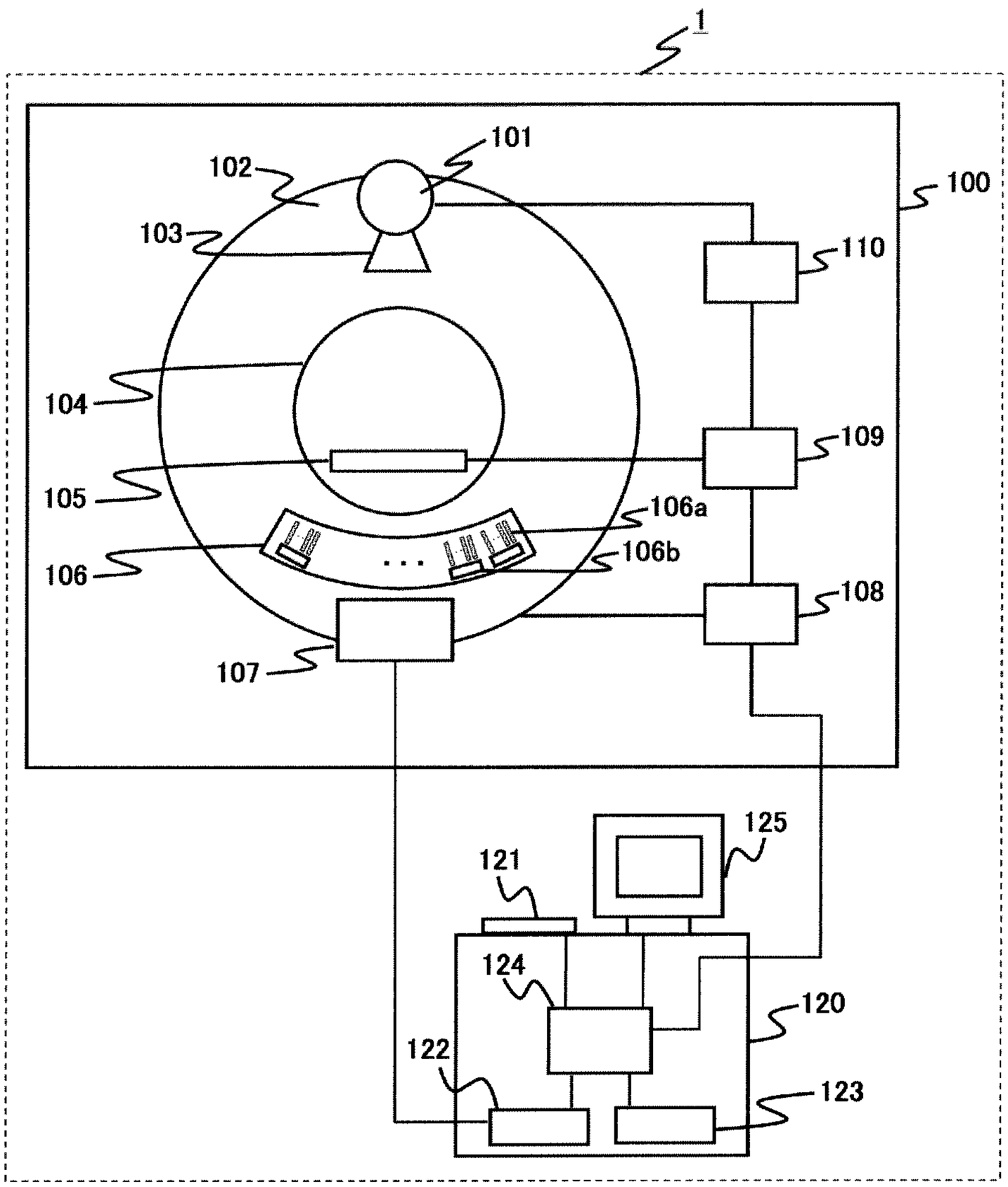

1
100
101
102
103
104
105
106
106a
106b
107
108
109
110
120
121
122
123
124
125

FIG. 2

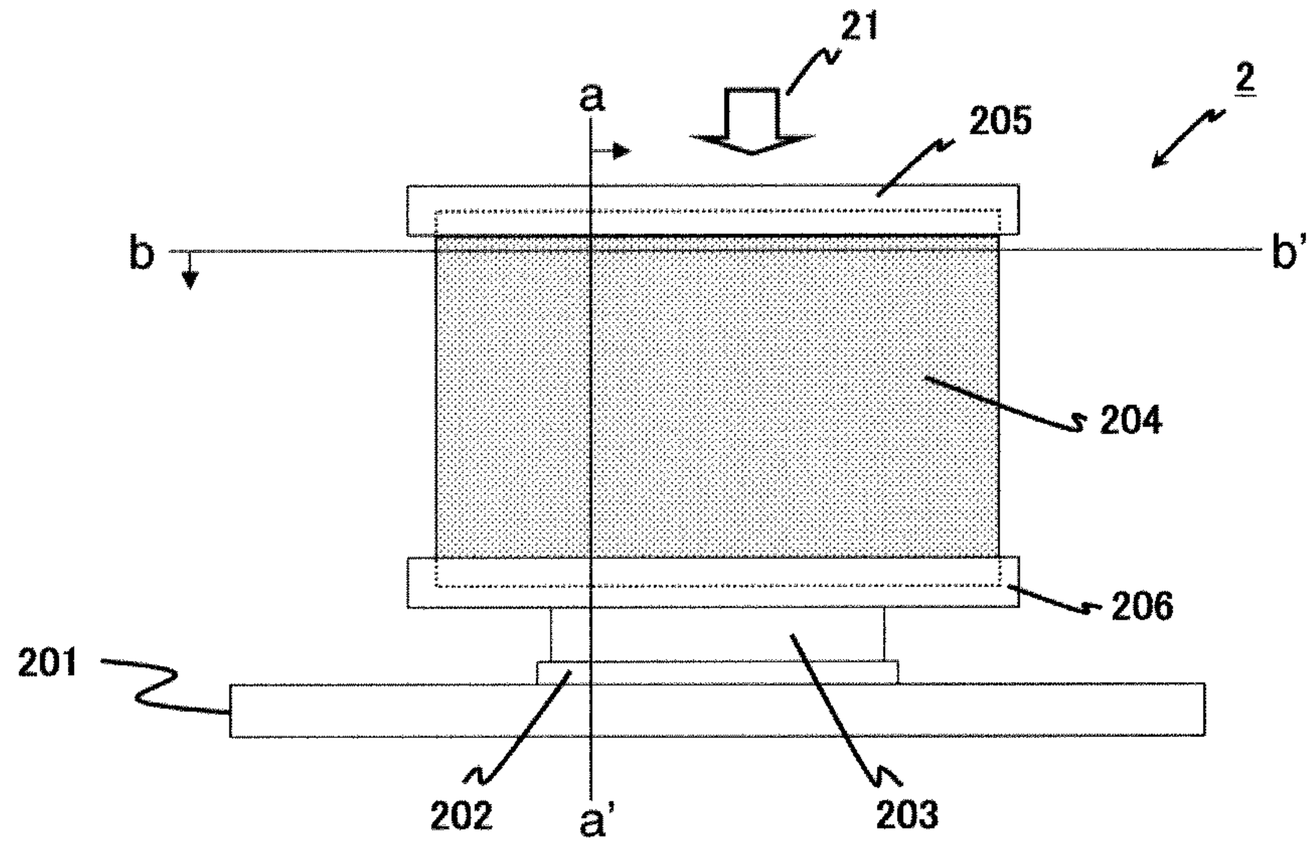

21
a
205
2
b
b'
204
206
201
202
a'
203

FIG. 3

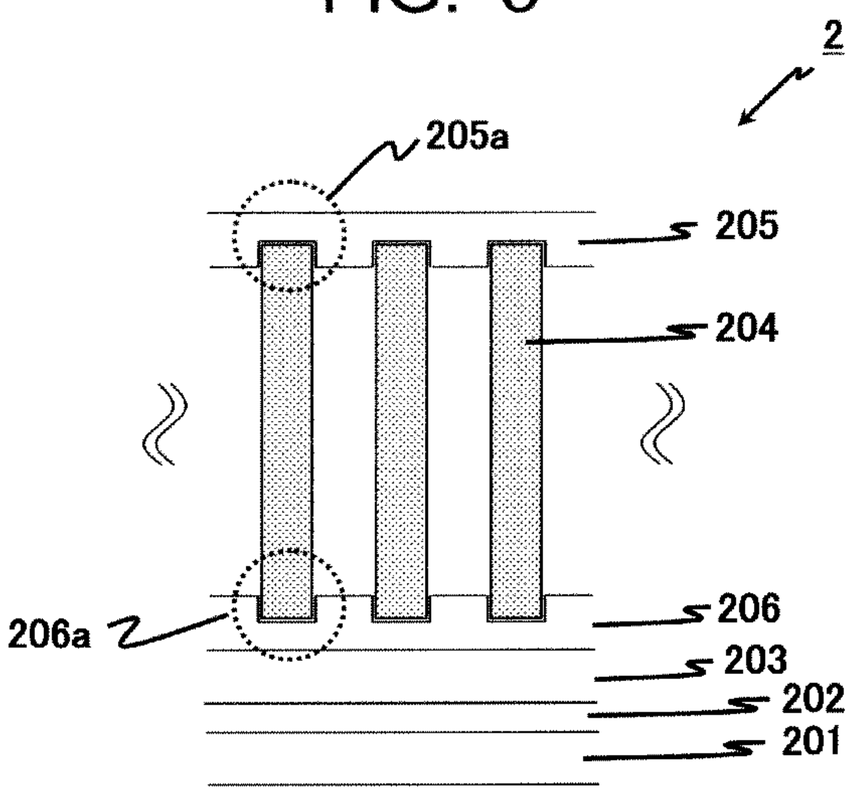

2
205a
205
204
206a
206
203
202
201

FIG. 4

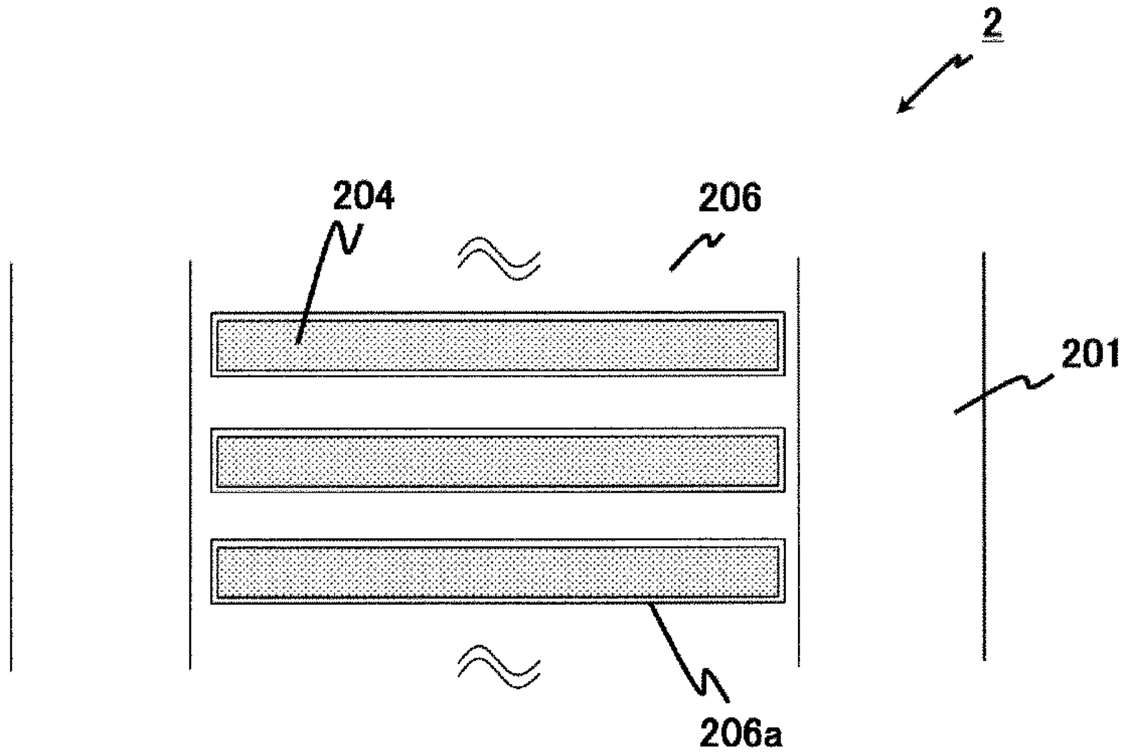


FIG. 5

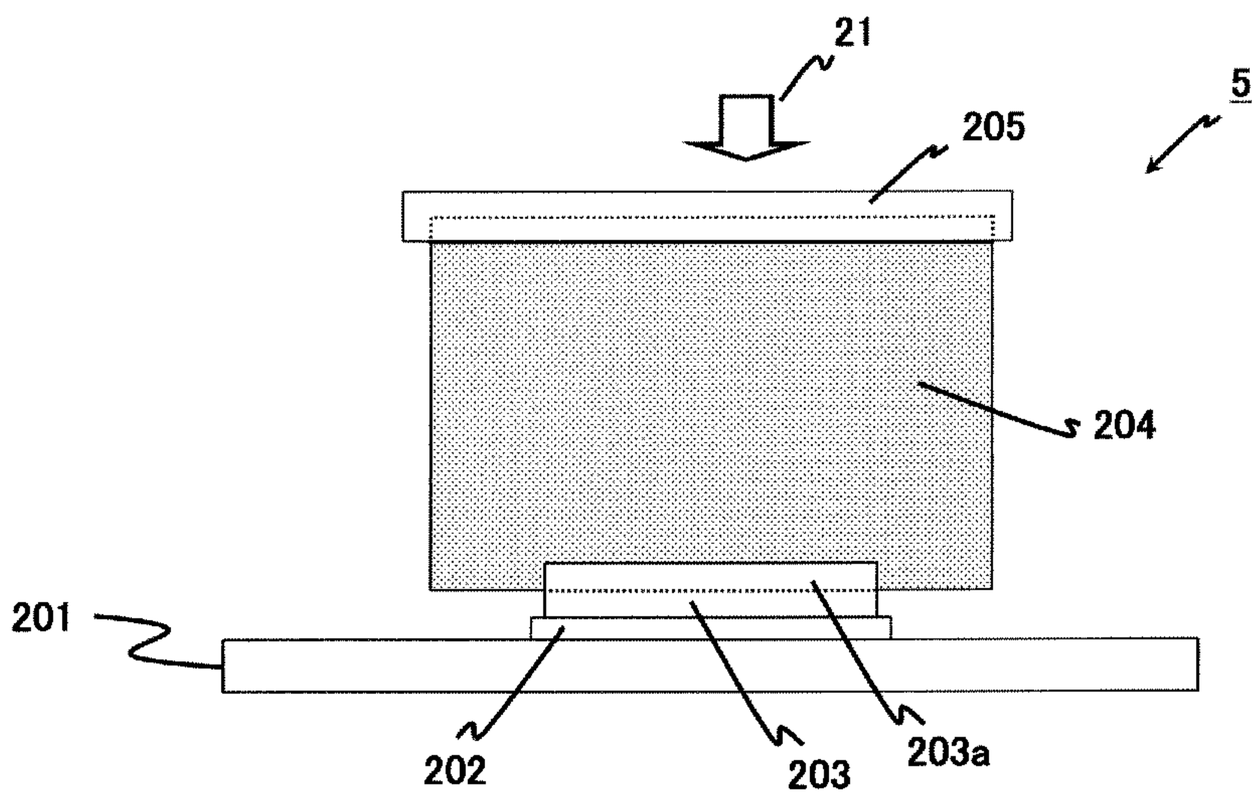


FIG. 6

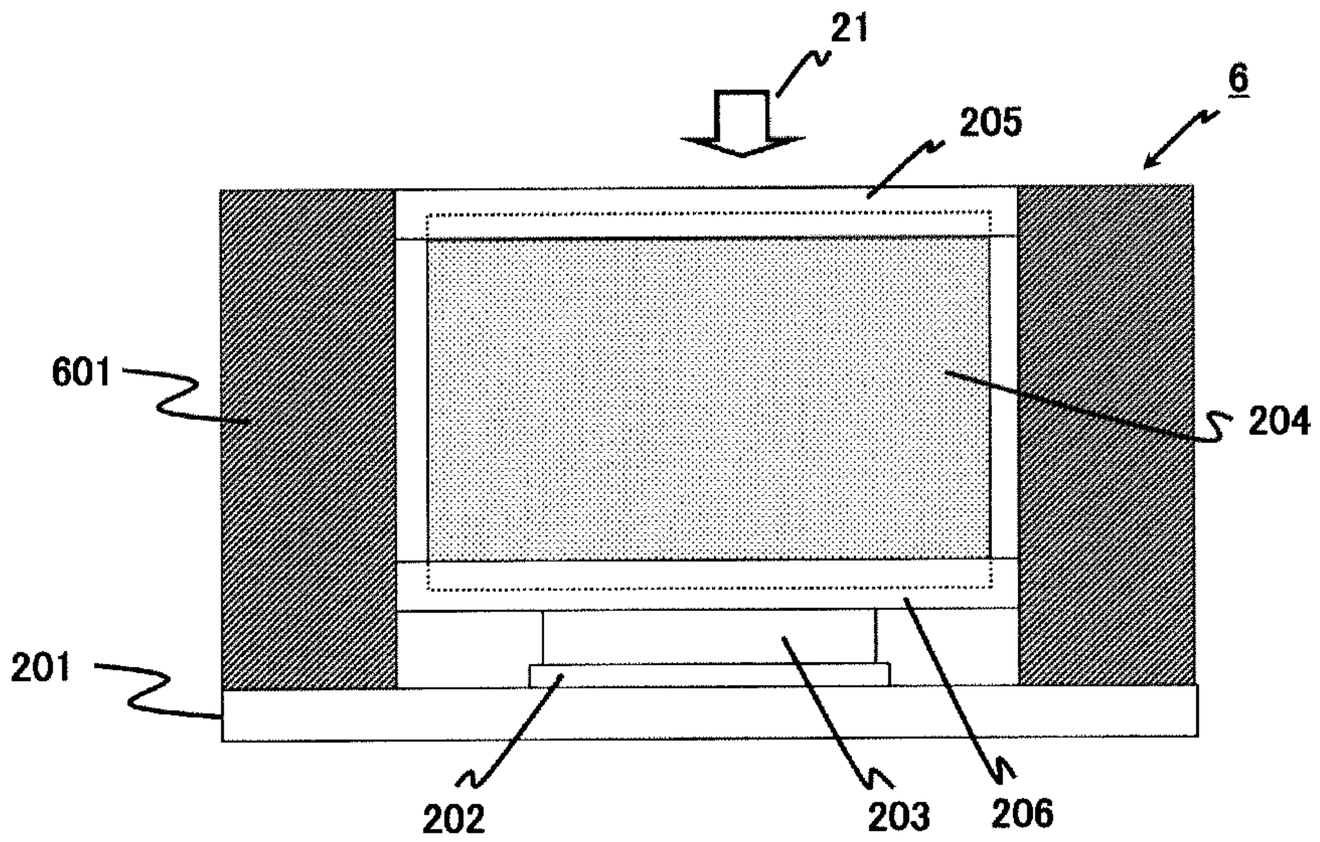


FIG. 7

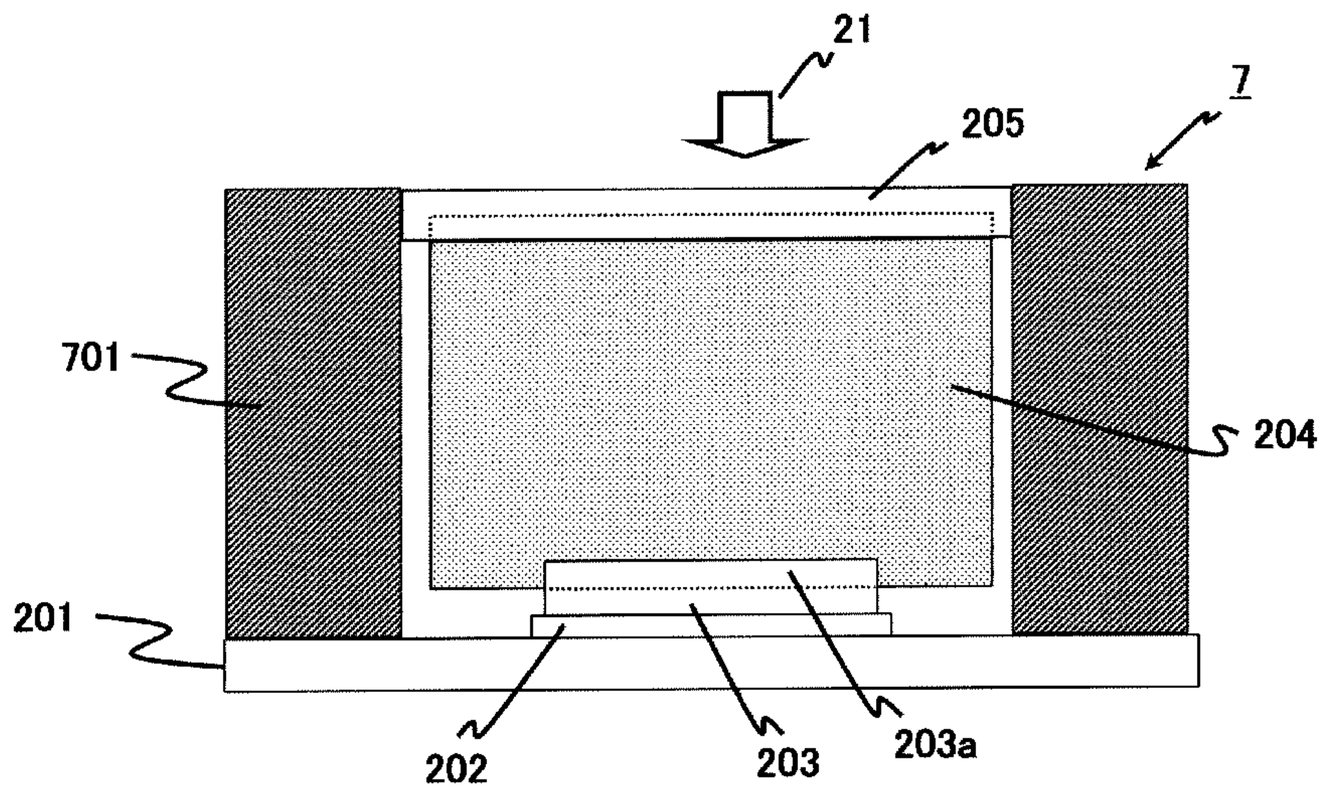


FIG. 8

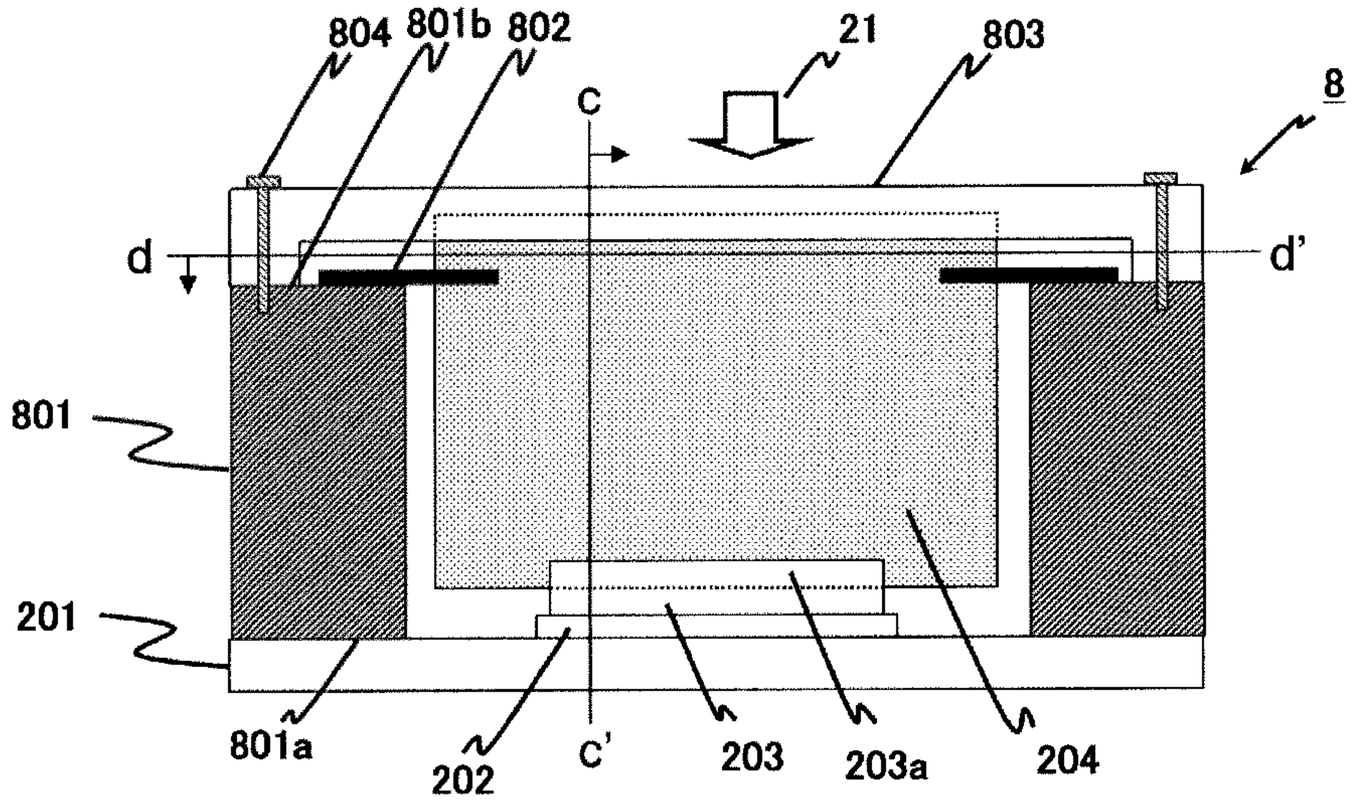

804
801b
802
21
803
8
C
d
d'
801
201
801a
202
C'
203
203a
204

FIG. 9

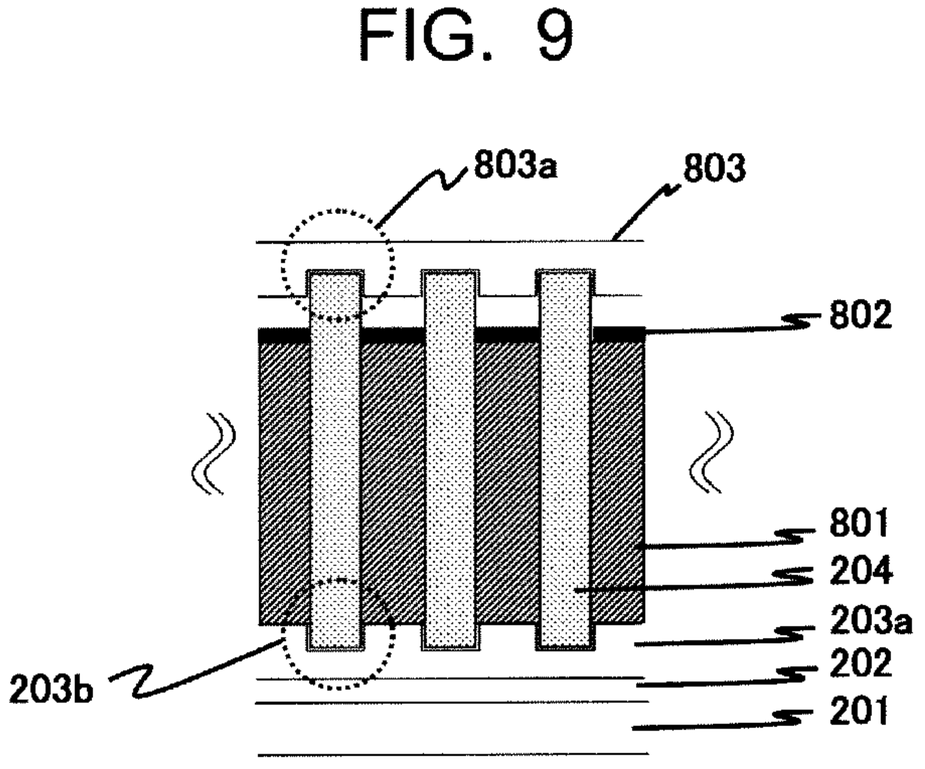

8
803a
803
802
801
204
203a
202
201
203b

FIG. 10

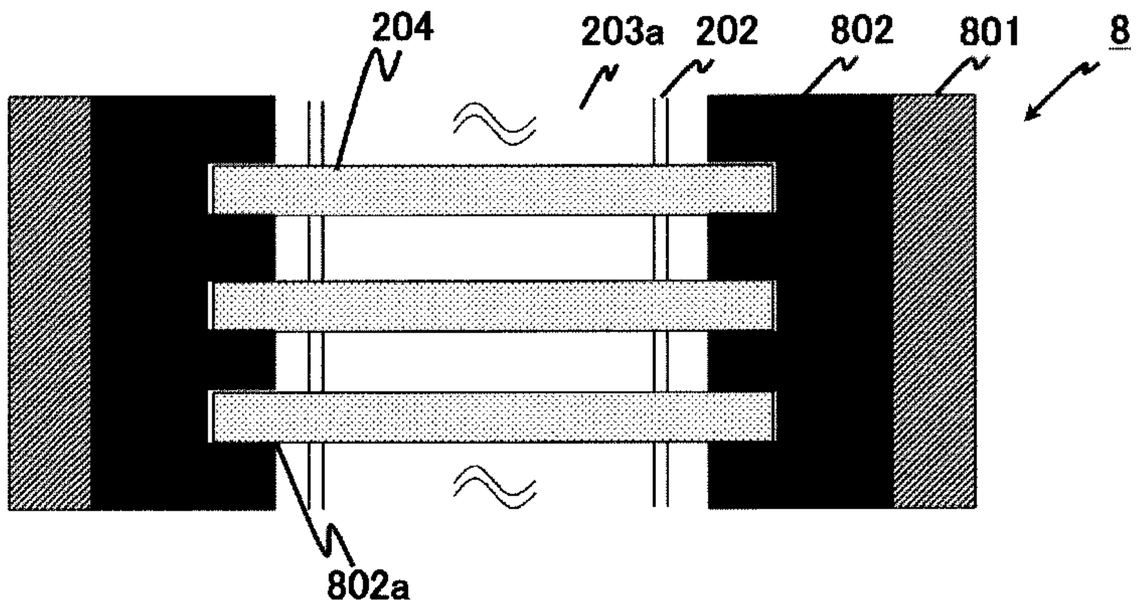

204
203a
202
802
801
8
802a

FIG. 11

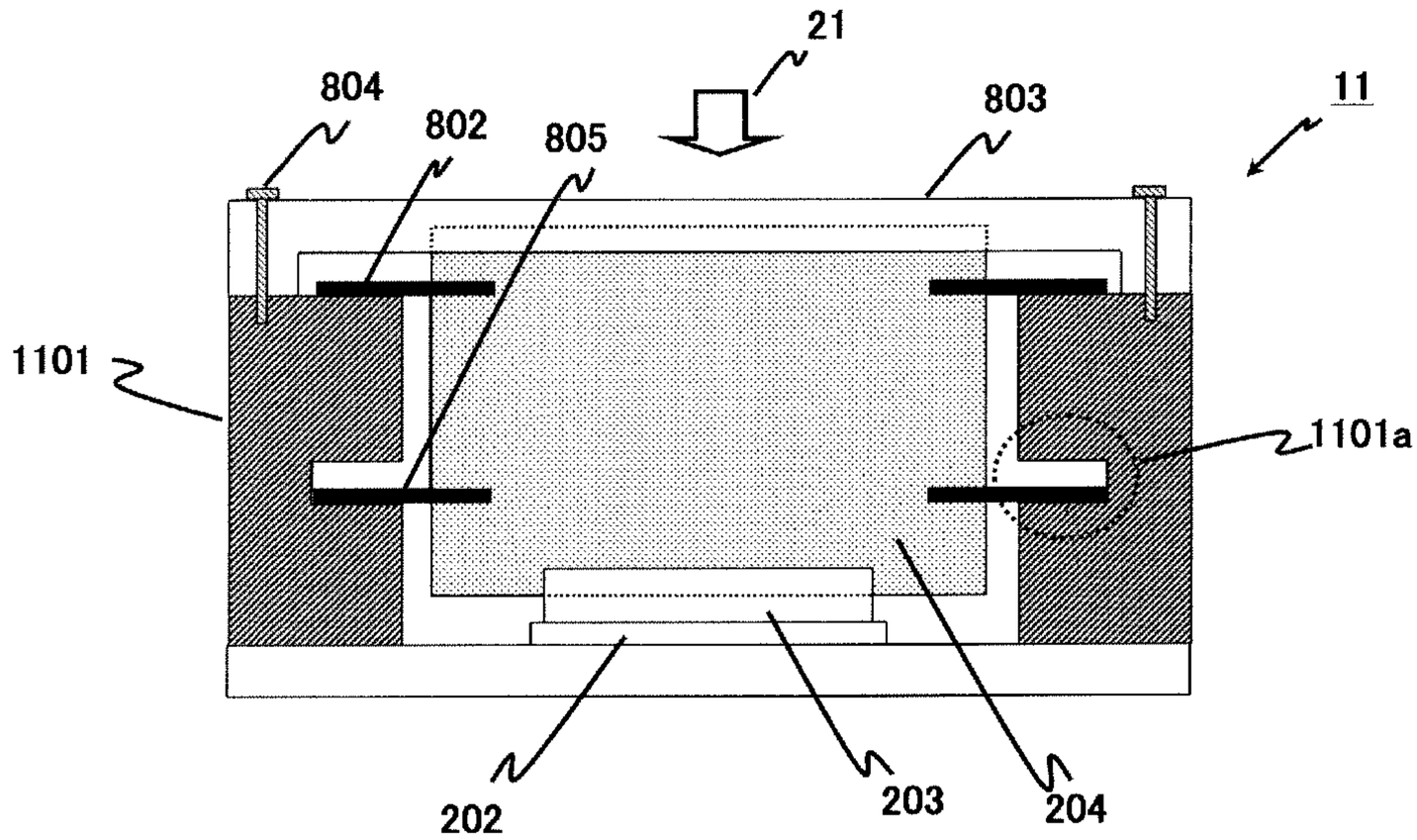

21
804
802
805
803
11
1101
1101a
202
203
204

FIG. 12

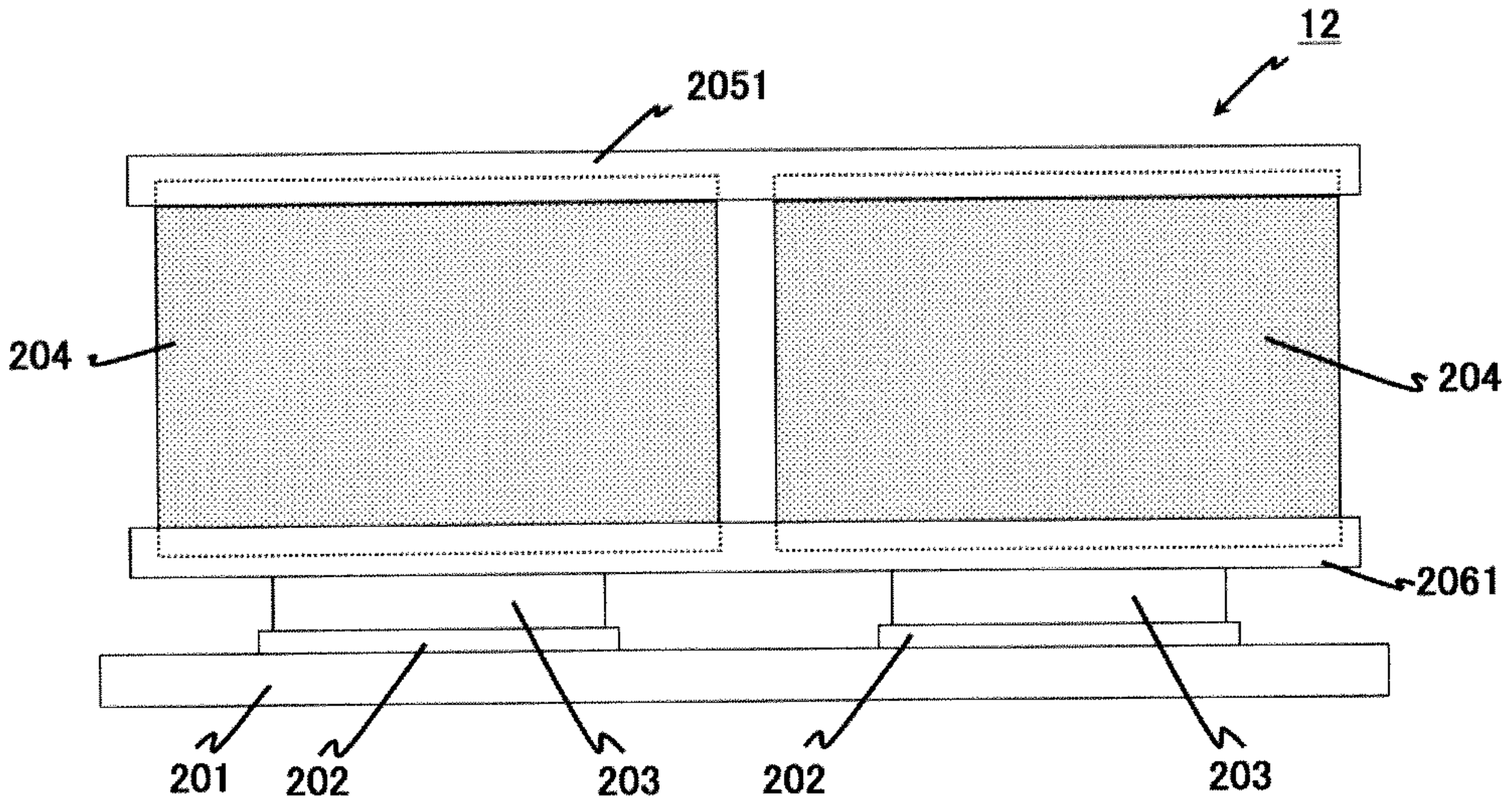
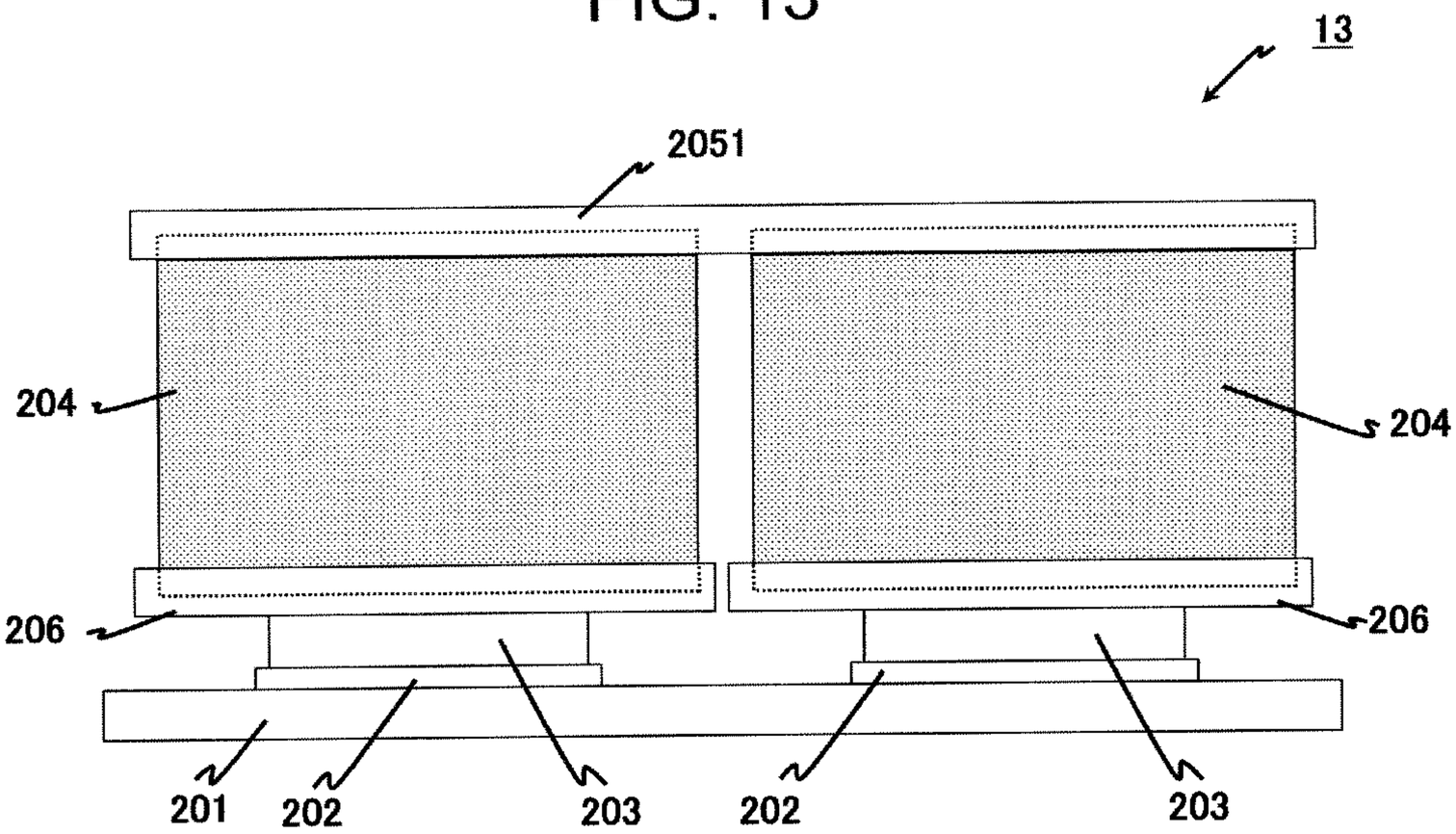

12
2051
204
204
2061
201
202
203
202
203

FIG. 13


13
2051
204
204
206
206
201
202
203
202
203

X-RAY DETECTOR AND X-RAY CT APPARATUS

TECHNICAL FIELD

The present invention relates to an X-ray detector which detects X-rays and in particular, to a technique for installing an X-ray detector in an X-ray CT apparatus appropriately.

BACKGROUND ART

A collimator plate is disposed to remove excessive scattered rays, which are incident on a scintillator that receives X-rays transmitted through an object, when scanning a part of the object with an X-ray CT apparatus (refer to PTL 1).

CITATION LIST

Patent Literature

[PTL 1] JP-A-8-243098

SUMMARY OF INVENTION

Technical Problem

In PTL 1, however, collimator plates arrayed at fixed distances in the circumferential direction of rotation of the X-ray CT apparatus and pillars for fixing both sides of the collimator plates from the rotation axis direction are provided. Grooves for placing the collimator plates are engraved on the pillars in order to fix the collimator plates at two places of both the sides.

For this reason, there has been concern regarding the occurrence of artifacts on a CT image due to deformation resulting from the insufficient strength of the collimator plate against the centrifugal force generated by the rotational movement of the X-ray CT apparatus. In addition, since a ceramic material or the like is used for the pillars and it is necessary to engrave as many grooves as the collimator plates, there has been a problem in that the ease of processing is not sufficient when using a ceramic material or the like that requires advanced processing.

Therefore, it is an object of the present invention to provide an X-ray detector, which can reduce the deformation of a collimator plate and can be easily processed and installed, and an X-ray CT apparatus using it.

Solution to Problem

In order to achieve the above-described object, the present invention is an X-ray detector including a collimator plate, and a scintillator array, a photoelectric conversion element array and a substrate that are bonded in order from an X-ray incidence direction. The collimator plate is disposed such that one of a pair of opposite sides of the collimator plate is bonded to a lower support plate bonded on the scintillator array and the other side is bonded to an upper support plate opposite the lower support plate and directions of the opposite sides are the same as a rotation axis direction of an X-ray CT apparatus in which the X-ray detector is provided. In addition, a pair of fixed pillars adjacent to two sides in a direction perpendicular to one side of the collimator plate bonded to the upper support plate are provided, and at least one of the upper support plate and the lower support plate is bonded to the fixed pillar.

Advantage of the Invention

According to the present invention, it is possible to provide an X-ray detector, which can reduce the deformation of a collimator plate and can be easily processed and installed, and an X-ray CT apparatus using it.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a view showing the entire configuration of an X-ray CT apparatus related to an embodiment of the present invention.

FIG. **2** is a view for explaining an X-ray detector of a first embodiment.

FIG. **3** is a view of an X-ray detector when FIG. **2** is seen from the cross section a-a'.

FIG. **4** is a view of an X-ray detector when FIG. **2** is seen from the cross section b-b'.

FIG. **5** is a view for explaining an X-ray detector of a second embodiment.

FIG. **6** is a view for explaining an X-ray detector of a third embodiment.

FIG. **7** is a view for explaining another X-ray detector of the third embodiment.

FIG. **8** is a view for explaining an X-ray detector of a fourth embodiment.

FIG. **9** is a view of an X-ray detector when FIG. **8** is seen from the cross section c-c'.

FIG. **10** is a view of an X-ray detector when FIG. **8** is seen from the cross section d-d'.

FIG. **11** is a view for explaining an X-ray detector of a fifth embodiment.

FIG. **12** is a view for explaining an X-ray detector of a sixth embodiment.

FIG. **13** is a view for explaining another X-ray detector of the sixth embodiment.

DESCRIPTION OF EMBODIMENTS

Hereinafter, an X-ray detector and an X-ray CT apparatus of the present invention will be described in detail according to the accompanying drawings. In addition, in all drawings for explaining the embodiments of the present invention, the same reference numerals are given to those with the same functions and repeated explanation thereof will be omitted.

FIG. **1** is a view showing the entire configuration of an X-ray CT apparatus to which the present invention is applied. The X-ray CT apparatus **1** includes a scan gantry unit **100** and a console **120**. The scanning gantry unit **100** includes an X-ray tube **101**, a rotary disk **102**, a collimator for an X-ray tube **103**, an X-ray detector **106**, a data acquisition device **107**, a bed **105**, a gantry controller **108**, a bed controller **109**, and an X-ray controller **110**. The X-ray tube **101** is a device which emits X-rays to an object placed on the bed **105**. The collimator for an X-ray tube **103** is a device which restricts the radiation range of X-rays emitted from the X-ray tube **101**. The rotary disk **102** includes an opening **104** through which the object placed on the bed **105** is inserted and also includes the X-ray tube **101** and the X-ray detector **106** mounted therein, and rotates around the object.

The X-ray detector **106** is a device which is disposed opposite the X-ray tube **101** and measures the spatial distribution of transmitted X-rays by detecting X-rays transmitted through the object. The X-ray detector **106** is formed by arraying a plurality of scintillator arrays **106***b* and a plurality of collimator plates **106***a* for removing excessive scattered rays, which are incident on the scintillator arrays **106***b*, in a

rotation direction of the rotary disk **102** or arraying the scintillator arrays **106***b* and the collimator plates **106***a* in a two-dimensional direction of the rotation direction of the rotary disk **102** and the rotation axis direction. The scintillator array **106***b* converts detected X-rays into visible light.

The converted visible light is converted into an electric signal by a photoelectric conversion element array (not shown in the drawing in particular), and the electric signal is transmitted to the data acquisition device **107**. The data acquisition device **107** is a device which acquires the amount of X-rays detected by the X-ray detector **106** as digital data. The gantry controller **108** is a device which controls the rotation of the rotary disk **102**. The bed controller **109** is a device which controls the bed **105** to move up and down and back and forth. The X-ray controller **110** is a device which controls electric power input to the X-ray tube **101**.

The console **120** includes an input device **121**, an image operation device **122**, a display device **125**, a storage device **123**, and a system controller **124**. The input device **121** is a device for inputting the name of the object, examination date and time, scanning conditions, and the like. Specifically, the input device **121** is a keyboard or a pointing device. The image operation device **122** is a device which reconstructs a CT image by performing arithmetic processing on the measurement data transmitted from the data acquisition device **107**. The display device **125** is a device which displays the CT image created by the image operation device **122**. Specifically, the display device **125** is a CRT (Cathode-Ray Tube), a liquid crystal display, or the like. The storage device **123** is a device which stores data acquired by the data acquisition device **107**, image data of the CT image created by the image operation device **122**, and data which is stored in advance at the time of product shipment so that object information on each scan protocol and the scanning length of an object in the body axis direction are correlated (hereinafter, referred to as "storage data"). Specifically, the storage device **123** is a HDD (Hard Disk Drive) or the like.

The system controller **124** is a device which controls these devices, the gantry controller **108**, the bed controller **109**, and the X-ray controller **110**. The X-ray controller **110** controls electric power input to the X-ray tube **101** on the basis of the scanning conditions input through the input device **121**, especially, on the basis of an X-ray tube voltage, an X-ray tube current, and the like, so that the X-ray tube **101** emits X-rays to the object according to the scanning conditions. The X-ray detector **106** detects X-rays, which are emitted from the X-ray tube **101** and transmitted through the object, using a plurality of X-ray detecting elements and measures the distribution of transmitted X-rays. The rotary disk **102** is controlled by the gantry controller **108** and rotates on the basis of the scanning conditions input through the input device **121**, especially on the basis of the rotation speed and the like. The bed **105** is controlled by the bed controller **109** and operates on the basis of the scanning conditions input through the input device **121**, especially on the basis of the helical pitch and the like.

X-ray emission from the X-ray tube **101** and measurement of the distribution of transmitted X-rays by the X-ray detector **106** are repeated while the rotary disk **102** is rotating. As a result, projection data from various angles is acquired. The acquired projection data from various angles is transmitted to the image operation device **122**. The image operation device **122** reconstructs a CT image by performing back projection processing on the transmitted projection data from various angles. The CT image obtained by reconstruction is displayed on the display device **125**.

First Embodiment

Next, a first embodiment of the present invention will be described using FIGS. **2** to **4**.

An X-ray detector **2** shown in FIG. **2** shows in detail a part of the X-ray detector **106** shown in FIG. **1**. In addition, the X-ray detector **106** shown in FIG. **1** is a view when seen from the rotation axis direction of the X-ray CT apparatus **1**, while the X-ray detector **2** shown in FIG. **2** is a view when seen from the circumferential direction of rotation of the X-ray CT apparatus **1**. FIG. **3** is the X-ray detector **2** when seen in the arrow direction from the cross section a-a' shown in FIG. **2**. FIG. **4** is the X-ray detector **2** when seen in the arrow direction from the cross section b-b' shown in FIG. **2**.

The X-ray detector **2** of the present embodiment is provided by bonding a scintillator array **203**, a photoelectric conversion element array **202**, and a substrate **201** in order from the direction of the incidence of X-rays (hereinafter, an X-ray incidence direction **21**).

A lower support plate **206** for fixing collimator plates **204** at approximately fixed distances in the circumferential direction of rotation of the X-ray CT apparatus **1** is provided on the surface of the scintillator array **203** facing the X-ray incidence direction **21** (hereinafter, an X-ray incidence surface). The lower support plate **206** is bonded to the X-ray incidence surface of the scintillator array **203** using an adhesive. The collimator plate **204** has a rectangular plate shape. One side of the collimator plate **204** is bonded to the lower support plate **206**, and another side opposite the one side is bonded and fixed to an upper support plate **205** facing the lower support plate using an adhesive or the like.

That is, the collimator plate **204** is placed in a form in which its two sides facing each other in the same direction as the rotation axis direction of the X-ray CT apparatus **1** are interposed in the lower support plate **206** and the upper support plate **205**, respectively. Although the collimator plate **204** has a rectangular shape in the present embodiment, it may have any polygonal shape with a pair of opposite sides.

A lower support plate groove **206***a* and an upper support plate groove **205***a* for positioning and placing the plurality of collimator plates **204** are provided in the lower support plate **206** and the upper support plate **205**, respectively. Since the plurality of collimator plates **204** are arrayed at approximately fixed distances in the circumferential direction of rotation of the X-ray CT apparatus **1**, the distance between the plurality of upper support plate grooves **205***a* provided in the upper support plate **205** is narrower than the distance between the plurality of lower support plate grooves **206***a* provided in the lower support plate **206** (not shown in the drawing in particular).

A resin material is used as a material of the lower support plate **206** and the upper support plate **205** in order to minimize attenuation of X-rays. As the resin material, there is polycarbonate or the like. By using polycarbonate injection molding by a mold, the lower support plate groove **206***a* and the upper support plate groove **205***a* can be easily formed in the lower support plate **206** and the upper support plate **205**, respectively.

As described above, in the X-ray detector **2** of the present embodiment, when placing the collimator plate **204**, two opposite sides of the collimator plate **204** with the same direction as the rotation axis direction of the X-ray CT apparatus **1** are disposed so as to be interposed in the lower support plate **206** and the upper support plate **205**, respectively. Accordingly, since the deformation of the collimator plate **204** by the centrifugal force generated by the rotational move-

ment of the X-ray CT apparatus can be reduced, artifacts on the CT image generated by the deformation can be reduced.

Second Embodiment

Next, a second embodiment of the present invention will be described using FIG. **5**.

An X-ray detector **5** shown in FIG. **5** is a view showing a different embodiment from FIG. **2** shown in the first embodiment. A different portion from the first embodiment will be described.

Compared with the X-ray detector **2** of the first embodiment, the X-ray detector **5** of the second embodiment does not use the lower support plate **206** for placing the collimator plate **204**. Instead of the lower support plate **206**, a scintillator groove **203***a* for positioning and fixing the collimator plate **204** is provided in a part of the X-ray incidence surface of the scintillator array **203**. The distance between the plurality of scintillator grooves **203***a* provided in the scintillator array **203** is wider than the distance between the upper support plate grooves **205***a* provided in the upper support plate **205** by the same reason as in the case of the first embodiment (not shown in the drawing in particular).

As described above, the X-ray detector **5** of the present embodiment does not need the lower support plate **206** since a groove is provided in a scintillator array **301** in order to place one side of the collimator plate **204** therein. Therefore, it is possible to form the lighter X-ray detector **5**.

Third Embodiment

Next, a third embodiment of the present invention will be described using FIG. **6**.

An X-ray detector **6** shown in FIG. **6** is a view showing a different embodiment from FIG. **2** shown in the first embodiment. A different portion from the first embodiment will be described.

Compared with the installation configuration of the collimator plate **204** of the X-ray detector **2** of the first embodiment, the lower support plate **206** and the upper support plate **205** are bonded using a pair of fixed pillars **601** which are adjacent to two sides in a direction perpendicular to one side of the collimator plate **204** bonded to the upper support plate **205**, respectively, in the X-ray detector **6** of the third embodiment. In addition, the fixed pillar **601** is bonded to the substrate **201**.

As described above, in the X-ray detector **6** of the present embodiment, deformation of the collimator plate **204** by the centrifugal force generated by the rotational movement of the X-ray CT apparatus can be more reduced than in the first embodiment by bonding the lower support plate **206** and the upper support plate **205** to the fixed pillar **601** bonded to the substrate **201**. As a result, artifacts on the CT image generated by the deformation can be reduced.

The present embodiment is not limited to this, and only the upper support plate **205** may be bonded using the fixed pillar **601**, for example, as in an X-ray detector **7** shown in FIG. **7**. In the X-ray detector **7** shown in FIG. **7**, the upper support plate **205** is bonded using the fixed pillar **601** compared with the X-ray detector **5** shown in FIG. **5**. In the X-ray detector **7** shown in FIG. **7**, the number of components can be reduced compared with that in the X-ray detector **6**. In addition, since the lower support plate **206** is not used, it is possible to eliminate attenuation of X-rays caused by the lower support plate **206**.

Fourth Embodiment

Next, a fourth embodiment of the present invention will be described using FIGS. **8** to **10**.

An X-ray detector **8** shown in FIG. **8** shows in detail a part of the X-ray detector **106** shown in FIG. **1**. In addition, the X-ray detector **106** shown in FIG. **1** is a view when seen from the rotation axis direction of the X-ray CT apparatus **1**, while the X-ray detector **8** shown in FIG. **8** is a view when seen from the circumferential direction of rotation of the X-ray CT apparatus **1**. FIG. **9** is the X-ray detector **8** when seen in the arrow direction from the cross section c-c' shown in FIG. **8**. FIG. **10** is the X-ray detector **8** when seen in the arrow direction from the cross section d-d' shown in FIG. **8**.

The X-ray detector **8** of the present embodiment includes a comb-shaped metal plate **802**, which has a comb-shaped groove **802***a* with a comb shape for fixing the plurality of collimator plates **204** toward the collimator plate **204**, at the top **801***b* opposite the bottom **801***a* of a fixed pillar **801** provided on the substrate **201**, and the collimator plate **204** is fixed by four parts of the comb-shaped metal plates **802**, the scintillator groove **203***a*, and an upper support plate **803**.

In order to form the comb-shaped groove **802***a*, a plurality of comb-shaped metal plates **802** are made to overlap and are then machined simultaneously by a diamond blade or a multi-wire saw. Thus, a plurality of comb-shaped metal plates **802** can be easily formed.

The comb-shaped metal plate **802** bonds a part of the side of the collimator plate **204** to the comb-shaped groove **802***a* while maintaining the positional relationship between grooves of the comb-shaped groove **802***a* and the scintillator groove **203***a*. Since the plurality of collimator plates **204** are radially arrayed in the circumferential direction of rotation of the X-ray CT apparatus **1** between adjacent collimator plates **204**, the distance between the comb-shaped grooves **802***a* and the distance between the scintillator grooves **203***a* may be different. More specifically, the distance between the comb-shaped grooves **802***a*, which are located further inward with respect to the rotation axis of the X-ray CT apparatus **1** than the scintillator grooves **203***a*, is narrower than the distance between the scintillator grooves **203***a*.

Similar to the upper support plate groove **205***a* provided in the upper support plate **205**, an upper support plate groove **803***a* for fixing one side of the collimator plate **204** is provided in the upper support plate **803**. Accordingly, more specifically, one side of the collimator plate **204** is bonded and fixed to the upper support plate groove **803***a* provided in the upper support plate **803**.

When placing the upper support plate **803**, the upper support plate groove **803***a* and the collimator plate **204** are aligned after all the collimator plates **204** on the substrate **201** are bonded by the comb-shaped groove **802***a* and the scintillator groove **203***a*, and the collimator plate **204** is fixed by the upper support plate **803** so as to cover the collimator plate **204**. In order to bond the upper support plate groove **803***a* and the collimator plate **204** to each other, it is preferable to use an adhesive or the like, which is cured at a temperature close to room temperature, so that the shrinkage of resin when cured is suppressed. In addition, the upper support plate **803** which fixes the collimator plate **204** is bonded to the top of the fixed pillar **801** with a screw **804**, an adhesive, or the like.

A resin material is used as a material of the upper support plate **803** in order to minimize attenuation of X-rays. As the resin material, there is polycarbonate or the like. When forming the upper support plate groove **803***a* with polycarbonate, the same method as the method when forming the upper support plate groove **205***a* can be used.

A material with which machining accuracy is easily obtained, such as ceramic or brass, is used for the fixed pillar **801**. Ceramic material is light but lacks ease of processing. In the present embodiment, however, it is not necessary to form a groove, which fixes the collimator plate **204**, with a ceramic material for each collimator plate **204** even if a ceramic material is used. Accordingly, the present embodiment can be executed without reducing the ease of processing.

The present embodiment is not limited to this, and it is needless to say that the present embodiment can also be applied to a case where the lower support plate **206** is used instead of the scintillator groove **203***a* to place the collimator plate **204**, for example.

As described above, in the X-ray detector **8** of the present embodiment, deformation of the collimator plate **204** by the centrifugal force generated by the rotational movement of the X-ray CT apparatus can be more reduced than in the third embodiment by fixing the collimator plate **204** from all sides by the comb-shaped metal plates **802**, the scintillator groove **203***a* or the lower support plate **206**, and the upper support plate **803**. As a result, artifacts on the CT image generated by the deformation can be reduced.

Fifth Embodiment

Next, a fifth embodiment of the present invention will be described using FIG. **11**.

In an X-ray detector **11** shown in FIG. **11**, the collimator plate **204** is fixed using a comb-shaped metal plate **805** further compared with the X-ray detector **8** shown in FIG. **8**.

The comb-shaped metal plate **805** has a comb-shaped groove (not shown in the drawing in particular) with a comb shape for fixing the collimator plate **204** in the same manner as the comb-shaped metal plate **802**, and its shape and material are the same as those of the comb-shaped metal plate **802**. The collimator plate **204** is fixed by the comb-shaped groove of the comb-shaped metal plate **805**.

The comb-shaped metal plate **805** is placed in a slit **1101***a* which is formed in the approximately middle portion of a fixed pillar **1101** so as to be approximately parallel to the substrate **201**. Even if a material, such as ceramic or brass, is used for the fixed pillar **1101** in the same manner as for the fixed pillar **801**, it is not necessary to form a groove corresponding to each collimator plate **204** with a ceramic material or brass. Accordingly, the present embodiment can be executed without reducing the ease of processing.

As described above, in the X-ray detector **11** of the present embodiment, deformation of the collimator plate **204** by the centrifugal force generated by the rotational movement of the X-ray CT apparatus can be reduced more than in the fourth embodiment by increasing the number of bonding places of the collimator plate **204** using the comb-shaped metal plate **805** in addition to the comb-shaped metal plate **802** so that it is fixed in a total of six places. As a result, artifacts on the CT image generated by the deformation can be reduced.

The present embodiment is not limited to this. It is also possible to provide a slit, which is formed in the same manner as the slit **1101***a*, in the fixed pillar **1101** and to increase the number of bonding places of the collimator plate **204** by placing the same comb-shaped metal plate as the comb-shaped metal plate **805** in the provided slit.

Sixth Embodiment

Next, a sixth embodiment of the present invention will be described using FIG. **12**.

An X-ray detector **12** shown in FIG. **12** is a view showing a case where a plurality of scintillator arrays **203** and a plurality of photoelectric conversion element arrays **202** are arrayed on the substrate **201** in the rotation axis direction of the X-ray CT apparatus **1**.

Here, each scintillator array **203** and each photoelectric conversion element array **202** will be described in detail. In each of the scintillator array **203** and the photoelectric conversion element array **202**, elements are arrayed in 16 columns in the rotation axis direction of the X-ray CT apparatus **1**, for example. By arraying a plurality of modules, for example, 16 modules on the substrate **201** with the scintillator array **203** and the photoelectric conversion element array **202**, each of which includes elements in 16 columns, as one module, it is possible to form an X-ray detector having detectors in many columns, such as 256 columns. The X-ray detector **12** shown in FIG. **12** is a view when two modules are arrayed. Dividing each module is due to various limitations on the manufacture of each element.

When a plurality of modules are arrayed in the rotation axis direction of the X-ray CT apparatus **1** as described above, the collimator plate **204** is disposed for each module and a plurality of collimator plates **204** (here, two collimator plates **204**) are fixed using one lower support plate **2061** and one upper support plate **2051**. Since the plurality of collimator plates **204** can be fixed at once compared with the case where the collimator plate **204** is fixed using a lower support plate and an upper support plate for each collimator plate **204**, the X-ray detector **12** can be easily configured.

Naturally, the collimator plate **204** may be fixed using a lower support plate and an upper support plate for each collimator plate **204**.

As described above, the X-ray detector **12** of the present embodiment can be easily configured by fixing the collimator plate **204** disposed in each module using one lower support plate **2061** and one upper support plate **2051** even when a plurality of modules are arrayed in the rotation axis direction of the X-ray CT apparatus **1**.

The present embodiment is not limited to this.

For example, as in an X-ray detector **13** shown in FIG. **13**, one upper support plate **2051** which fixes the plurality of collimator plates **204** and the lower support plate **206** which is used for each collimator plate **204** may be used in combination when fixing the plurality of collimator plates **204**.

DESCRIPTION OF REFERENCE NUMERALS AND SIGNS

1: X-ray CT apparatus
2, **5**, **6**, **8**: X-ray detector
21: X-ray incidence direction
100: scan gantry unit
101: X-ray tube
102: rotary disk
103: collimator for an X-ray tube
104: opening
105: bed
106: X-ray detector
106*a*, **204**: collimator plate
106*b*: scintillator array
107: data acquisition device
108: gantry controller
109: bed controller

110: X-ray controller
120: console
121: input device
122: image operation unit
123: storage device
124: system controller
125: display device
201: substrate
202: photoelectric conversion element array
203: scintillator array
203*a*: scintillator groove
205, **2051**: upper support plate
205*a*: upper support plate groove
206, **2061**: lower support plate
206*a*: lower support plate groove
301: scintillator array
601, **801**: fixed pillar
801*a*: bottom
801*b*: top
802: comb-shaped metal plate
802*a*: comb-shaped groove
803: upper support plate
803, **803***a*: upper support plate groove
804: screw
805: comb-shaped metal plate
1101: fixed pillar
1101*a*: slit

The invention claimed is:

1. An X-ray detector comprising a collimator plate, and a scintillator array, a photoelectric conversion element array and a substrate that are bonded in order from an X-ray incidence direction, wherein in the collimator plate, one of a pair of opposite sides of the collimator plate is bonded to an X-ray incidence surface of the scintillator array and the other side is bonded to an upper support plate, and at least one place of each of two sides of the collimator plate in a direction perpendicular to the opposite sides is bonded by a comb-shaped metal plate, and wherein the comb-shaped metal plate has a groove which is parallel to the opposite sides, and

wherein the comb-shaped metal plate is parallel to the X-ray incident surface of the scintillator array.

2. The X-ray detector according to claim **1**,

wherein a pair of fixed pillars adjacent to two sides in a direction perpendicular to one side of the collimator plate bonded to the upper support plate are provided, and

the upper support plate and the comb-shaped metal plate are bonded to the fixed pillars.

3. The X-ray detector according to claim **2**, wherein a slit is provided in an approximately middle portion, in the X-ray incidence direction, of the fixed pillar so as to be approximately parallel to the substrate, and the comb-shaped metal plate is bonded to the slit.

4. An X-ray CT apparatus comprising:

an X-ray source which emits X-rays to an object;

an X-ray detector which is disposed opposite the X-ray source in order to detect X-rays transmitted through the object;

a rotary disk in which the X-ray source and the X-ray detector are mounted and which rotates around the object;

an image reconstruction device which reconstructs a tomographic image of the object on the basis of the amount of transmitted X-rays detected by the X-ray detector; and

an image display device which displays the tomographic image reconstructed by the image reconstruction device,

wherein the X-ray detector is the X-ray detector according to claim **1**.

5. The X-ray CT apparatus according to claim **4**, wherein the collimator plate is disposed such that one of a pair of opposite sides of the collimator plate is bonded to a lower support plate bonded on the scintillator array and the other side is bonded to an upper support plate and directions of the opposite sides are the same as a rotation axis direction of the X-ray CT apparatus.

6. The X-ray CT apparatus according to claim **5**, wherein a pair of fixed pillars adjacent to two sides in a direction perpendicular to one side of the collimator plate bonded to the upper support plate are provided, and at least one of the upper support plate and the lower support plate is bonded to the fixed pillars.

7. The X-ray CT apparatus according to claim **4**, wherein the collimator plate is disposed such that one of a pair of opposite sides of the collimator plate is bonded to an X-ray incidence surface of the scintillator array and the other side is bonded to an upper support plate and directions of the opposite sides are the same as a rotation axis direction of the X-ray CT apparatus.

8. The X-ray CT apparatus according to claim **7**, wherein a pair of fixed pillars adjacent to two sides in a direction perpendicular to one side of the collimator plate bonded to the upper support plate are provided, and the upper support plate is bonded to the fixed pillars.

9. The X-ray detector according to claim **1**, wherein the upper support plate is bonded to the collimator plates after the comb-shaped metal plate is bonded to all of the collimator plates.

* * * * *